

b. half way to the equivalence point.

c. at the equivalence point. (E9)

SELF-TEST

A. Multiple Choice:

- The K_a of benzoic acid is 1×10^{-5} . Which of the following would you choose as a pH = 4.0 buffer?
 - A 1.0 M solution of benzoic acid
 - A 1.0 L solution containing 1.0 mole of benzoic acid and 1.0 mole of sodium benzoate
 - A 1.0 L solution containing 1.0 mole of benzoic acid and 0.10 mole of sodium benzoate
 - A 1.0 L solution containing 0.10 mole of benzoic acid and 1.0 mole of sodium benzoate
- Which of the following indicators is most suitable for the titration of 0.1 M ammonia with 0.1 M HCl?

a. cresol red	pH range	0.2 – 1.2
b. methyl red	pH range	4.2 – 6.2
c. neutral red	pH range	7.0 – 8.2
d. thymol blue	pH range	8.0 – 9.6
e. alizarin yellow	pH range	10.1 – 12.6
- A buffered solution contains 0.100 mol sodium acetate and 0.100 mol acetic acid. Its pH is 4.7. One gram of NaOH (0.025 mol) is added to the buffer. What is the pH of the solution after the NaOH has been dissolved?
 - less than 4
 - near 4.7
 - 7.0
 - 12.4
- Which of the following relationships applies to a solution made by adding 0.150 mol of weak base, B^- , to water to make one liter of solution?
 - $[B^-] = [OH^-]$
 - $[B^-] = [HB]$
 - $[B^-] + [OH^-] = 0.15 \text{ M}$
 - $[HB] + [OH^-] = 0.15 \text{ M}$

5. One liter solutions with the following reagents are prepared. Which ones are buffers?

- (1) 0.05 mol HCl and 0.1 mol NH_3
- (2) 0.1 mol HCl and 0.05 mol NH_3
- (3) 0.1 mol NH_4Cl and 0.05 mol NH_3
- (4) 0.1 mol NaOH and 0.05 mol NH_4Cl
- (5) 0.05 mol NaOH and 0.1 mol NH_4Cl

- a. (3)
- b. (1),(2),(3)
- c. (2),(3),(4)
- d. (1),(3),(5)
- e. (1),(2),(3),(4),(5)

6. The indicator phenolphthalein is red at a pH greater than 9. Which of the following solutions would turn red when phenolphthalein is added?

- (1) 1×10^{-10} M solution of HCl
- (2) 1×10^{-2} M solution of NaOH
- (3) equal volumes of 1×10^{-2} M solutions of NaOH and NaF
- (4) equal volumes of 1×10^{-2} M solutions of NaOH and HNO_3

- a. (2)
- b. (1),(2)
- c. (2),(3)
- d. (2),(4)
- e. (1),(2),(3)
- f. (1),(2),(4)

7. The indicator methyl red has a K_a of about 1×10^{-5} . Its "acid" form is red, while its "basic" form is yellow. What is the color of a solution with a pH of 5 to which a few drops of methyl red have been added?

- a. red
- b. yellow
- c. green
- d. orange
- e. colorless

8. Which of the following equations best describes what takes place *just after the equivalence point is reached* in the titration of the weak base ClO^- (aq) with hydrobromic acid?

- a. $\text{H}^+ (\text{aq}) + \text{ClO}^- (\text{aq}) \rightarrow \text{HClO} (\text{aq})$
- b. $\text{HClO} (\text{aq}) \rightleftharpoons \text{H}^+ (\text{aq}) + \text{ClO}^- (\text{aq})$
- c. $\text{ClO}^- (\text{aq}) + \text{H}_2\text{O} \rightleftharpoons \text{HClO} (\text{aq}) + \text{OH}^- (\text{aq})$
- d. $\text{HClO} (\text{aq}) + \text{OH}^- (\text{aq}) \rightarrow \text{H}_2\text{O} + \text{ClO}^- (\text{aq})$
- e. $\text{ClO}^- (\text{aq}) + \text{Br}^- (\text{aq}) \rightarrow \text{ClOBr}^{2-} (\text{aq})$

9. Which of the following is the net ionic equation for the reaction that occurs when small amounts of HCl (aq) are added to the $\text{HNO}_2/\text{NaNO}_2$ system?

- a. $\text{H}^+ (\text{aq}) + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+$
- b. $\text{H}^+ (\text{aq}) + \text{NO}_2^- (\text{aq}) \rightarrow \text{HNO}_2 (\text{aq})$
- c. $\text{HNO}_2 (\text{aq}) \rightarrow \text{H}^+ (\text{aq}) + \text{NO}_2^- (\text{aq})$
- d. $\text{H}^+ (\text{aq}) + \text{HNO}_2 (\text{aq}) \rightarrow \text{H}_2\text{NO}_2^+ (\text{aq})$
- e. $\text{HCl} (\text{aq}) + \text{NaNO}_2 (\text{aq}) \rightarrow \text{HNO}_2 (\text{aq}) + \text{NaCl} (\text{aq})$

10. Which of the following statements is true about the titration of a weak monoprotic base with a strong acid such as HNO_3 ? At the equivalence point
- the pH is 7.
 - the number of moles of weak base is greater than the number of moles of strong acid added.
 - phenolphthalein ($K_a \approx 1 \times 10^{-10}$) turns pink.
 - the resulting solution is a buffer.
 - the resulting solution is acidic.

B. Less than, Equal to, Greater than

Consider 2 beakers. Beaker A has 50.0 mL of 0.10 M HCl. Beaker B has 50.0 mL of 0.10 M $\text{HC}_2\text{H}_3\text{O}_2$ ($K_a = 1.8 \times 10^{-5}$). Both are to be titrated with a solution of 0.10 M NaOH. Answer questions 1 – 4 below, using **LT** (for *less than*), **GT** (for *greater than*), **EQ** (for *equal to*), or **MI** (for *more information required*) in the blanks provided.

- _____ 1. At the equivalence point, the volume of NaOH used to titrate HCl in Beaker A is (1) _____ the volume of NaOH used to titrate $\text{HC}_2\text{H}_3\text{O}_2$ in Beaker B.
- _____ 2. When each solution has reached its equivalence point, the pH of the solution in Beaker A is (2) _____ the pH of solution in Beaker B.
- _____ 3. Before titration starts (at zero time), the pH of the solution in Beaker A is (3) _____ the pH of the solution in Beaker B.
- _____ 4. At half-neutralization (halfway to the equivalence point), the pH of the solution in Beaker A is (4) _____ the pH of the solution in Beaker B.
- _____ 5. The effective range for the indicator used in the titration of Beaker B (5) _____ the effective range for the indicator used in the titration of Beaker A.

Consider the following titrations. What would the pH be at the equivalence point with respect to 7?

- _____ 6. HCl with NaF
- _____ 7. HCHO_2 with KOH
- _____ 8. HCl with KOH
- _____ 9. HCHO_2 with NaF

C. True or False:

Consider the titration of a weak acid with sodium hydroxide.

- _____ 1. The pH is 7 at the equivalence point.
- _____ 2. $[\text{H}^+]$ is less than $[\text{OH}^-]$ after the equivalence point is reached.
- _____ 3. As base is added the pH increases slowly then a large increase occurs.
- _____ 4. As base is added the pH increases until the half equivalence point is reached, then the pH remains constant as more base is added.
- _____ 5. At the half equivalence point the $[\text{H}^+] = K_a$.
- _____ 6. Before the half equivalence point the concentration of the weak acid is less than the concentration of its conjugate base.

D. Problems:

Consider ammonia, NH_3 .

1. What is the pH of a buffer solution prepared by adding 15.0 g of ammonium chloride to 5.00 L of 0.200 M ammonia?
2. What is the pH of the buffer after 90.0 mL of 2.00 M HCl are added?

3. What is the pH of the buffer after 5.00 g of NaOH are added?

4. What is the pH of the buffer after 15.00 g of NaOH are added?

5. How many grams of ammonium chloride are needed for 5.00 L of 0.200 M ammonia to make a buffer with a pH of 10.50?

6. If 50.0 mL of 0.200 M solution of ammonia are titrated with 0.100 M solution of HNO_3 , what volume of HNO_3 is required to reach the equivalence point? What is the pH at that point?
7. If the titration in (6) stops half way to the equivalence point, what is the pH of the solution at that point?

ANSWERS**Exercises:**

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|--|--|
| (E1) 6.36 | (E2) 32 g |
| (E3) 9.38 | (E4) 9.36 |
| (E5) 9.58 | (E6) 13.58 |
| (E7) (1) 0.602 (2) 1.02 (3) 7.00 | (E8) (1) 11.13 (2) 9.26 (3) 5.21 |
| (E9) a. 2.63 b. 4.85 c. 9.04 | |

Self-Test**A. Multiple Choice:**

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|------|------|------|------|-------|
| 1. c | 2. b | 3. b | 4. c | 5. d |
| 6. c | 7. d | 8. b | 9. b | 10. e |

B. Less than, Equal to, Greater than:

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|-------|-------|-------|-------|-------|
| 1. EQ | 2. LT | 3. LT | 4. LT | 5. GT |
| 6. LT | 7. GT | 8. EQ | 9. MI | |

C. True or False:

- | | | | | |
|------|------|------|------|------|
| 1. F | 2. T | 3. T | 4. F | 5. T |
| 6. F | | | | |

D. Problems:

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|----------|------------------|----------|----------|
| 1. 9.80 | 2. 9.50 | 3. 10.11 | 4. 12.28 |
| 5. 3.0 g | 6. 0.100 L; 5.21 | 7. 9.26 | |